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Three Reports Concerning the Tortugas Sanctuary Studies, 1981-1982

Report I. The Tortugas Sanctuary Study, May 1981-February 1982; Edward F. Klima and Thomas Costello.

Report II. A Preliminary Analysis of Pink Shrimp (Penaeus duorarum) Size and Abundance During the Tortugas Shrimp Sanctuary Study, September 1981-February 1982; Terrell W. Roberts.

Report III. A Synopsis of the Tortugas Pink Shrimp Fishery, 1960-19681, and the Impact of the Tortugas Sanctuary; Edward F. Klima, Geoffrey A. Matthews, Frank J. Patella.

U. S. DEPARTMENT OF COMMERCE
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REPORT III

A SYNOPSIS OF THE TORTUGAS PINK SHRIMP FISHERY, 1960-1981, AND THE IMPACT OF THE TORTUGAS SANCTUARY

by

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INTRODUCTION

The implementaiton of the Gulf of Mexico Shrimp Fishery Management Plan on May 15, 1981 established an area commonly known as the Tortugas shrimp sanctuary and prohibited all trawling activity within that area (Gulf of Mexico Fishery Management Council, 1980). The basis of this regulation was founded in scientific information which indicated that the sanctuary is a primary nursery area for the Tortugas shrimp stocks and that recruitment to the offshore fishery is dependent on the sanctuary. Further, Lindner (1965) and Berry (1969), utilizing growth and mortality information, indicated that the yield of pink shrimp would be greater if harvest was delayed until shrimp are larger than the minimum legal size for harvesting in Florida. Therefore, the concept of the Gulf of Mexico Fishery Management Council in re-establishing the sanctuary was to protect small, undersized shrimp from fishing. Furthermore, it was assumed that the distribution of small shrimp was confined mainly inside the sanctuary line and that outside the line shrimp were of a legal size or larger. Thus, the establishment of a permanent sanctuary would result in a greater yield (Gulf of Mexico Fishery Management Council, 1980).

This report reviews and analyzes the characteristics of the Tortugas fishery from the inception of the closure in May 1981 through December 1981 and compares this information with the historical record. These comparisons include catch, effort, size composition and catch per unit effort (CPUE). We determined whether these characteristics were affected by the regulations. This report is to be considered along with the report developed by Roberts (MS) providing details of the size distribution and abundance of pink shrimp from September 1981 to February 1982.

MATERIALS AND METHODS

Collection of detailed catch statistics describing the U.S. Gulf of Mexico shrimp fishery are available since 1956 and the procedures used to collect them are described by Klima (1980). The statistics compiled by the Southeast Fisheries Center (SEFC), Technical Information Management Services (TIMS), consisting of catch by statistical area (Fig 1), effort data (in 24 hrs of fishing, time expressed as days fished) and size composition of the catch were used to analyze the effects of the Tortugas shrimp sanctuary . Locations and amount of fishing effort expended in 24 hrs fishing were obtained by interviewing fishing vessel captains at the termination of their trips. All catch data were recorded as heads-off by species and size category, by statistical subarea, depth zone and month. These data were used to compile CPUE per 24 hrs of fishing and are reported in "Fishery Statistics of the United States (1956-1979)" and "Shrimp Landings (1956-1979)". Data from 1980 to the present are on file at the SEFC TIMS office and are available for inspection by interested parties. Mr. Ernest Snell (SEFC, TIMS) has provided specific information concerning the Tortugas shrimp fishery relative to fleet activities, changes in the fleet, number of trips, discards and specifics of catch and effort for the fishing area during 1981.

Catch data frequently follow skewed distribution, show heteroscedasticity and have non-additive components. Transformations applied to the original data are often able to alleviate these problems and permit valid statistical analysis of the data employing t-tests and 2-way analysis of variance (ANOVA) (Sokal and Rohlf, 1969). Taylor's (1961) test analyzing relationships between means and variances showed the shrimp catch data should be transformed logarith-

mically and CPUE data should be transformed by the inverse of their square roots. The analysis of these transformed data provided statistical support to what the untransformed data showed and the summaries are presented here with untransformed data.

Statistical Tests

Mean monthly catch and mean CPUEs for the 1960-1979 period were compared with the 1981 monthly data via 2-way ANOVA and Student-Newman-Keuls (SNK) tests. Additional comparisons between monthly means of the fisheries data for the five earliest years (1960-1964), the five latest years (1975-1979) and the 1981 monthly data were made by paired t-tests. The shrimp size distributions for each month were compared with each of the three historical data sets and 1981 monthly size distributions using G-tests (Sokal and Rohlf, 1969). Unless otherwise stated, tests of significance were performed at the 95% level (P = 0.05) (Rohlf and Sokal, 1969).

Fishery Background

The Tortugas pink shrimp (Penaeus duorarum) fishing grounds were discovered in 1949 and by 1950, a major commercial shrimp fishery had developed. Regan et al. (1959) reported a decline in the landings of larger shrimp and possible depletion of the stock caused by landings of small shrimp (70-count and above, heads off). Costello[1] has reviewed the state of Florida's regulations relating to the pink shrimp fishery and summarizes these from 1955 to the present. He identified the State's concern about possible over-exploitation and the concern over large catches of very small pink shrimp that were not saleable and were probably

[1]Costello, T. J. DOC/NOAA/NMFS/SEFC, Miami, FL; personal communication.

discarded at sea. To prevent wastage and discard of small shrimp, the Florida State Board of Conservation set regulations specifying the minimum legal size of mesh allowed in the codends of shrimp trawls used on the Tortugas grounds and also established a minimum size limit for shrimp. Florida closed a part of the Tortugas fishing grounds to fishing in 1957 to prevent large catches of small shrimp. Caillouet and Koi (1981) considered the influences of major changes in regulations concerning the fishery, in exploring possible causes of annual fluctuations in size composition of the reported catches from 1960-1978.

The Fleet

Shrimp trawlers fishing the Tortugas grounds operate out of Key West, Marathon, Fort Myers, Tampa, St. Petersburg and Tarpon Springs, FL. From January to April 1982, approximately 590 shrimp trawlers worked the Tortugas shrimping grounds. The number of trawlers decreased during the months of May-August, but by October had increased (Table 1). The major fishing season in the Tortugas runs from October through May of each year. During the summer months, the majority of the Tortugas fleet migrates to the northern Gulf, where some Florida dealers open packing houses for their established fleets (Ernest Snell)[2]. These trawlers return to the southern area by late October to again fish the Tortugas fishing grounds.

Major changes in the fleet have been the addition in 1979 of "quad-rigs" or "twin trawls" and the use of freezer holds. Approximately 90% of vessels with 350 HP engines now use quad-rigs, whereas only 60% of vessels with less than 350 HP are so equipped. The use of freezer holds by some

[2,3]Snell, Ernest J. DOC/NOAA/NMFS/SEFT/TIMS, Miami, FL; personal communication.

trawlers began in 1968. Snell[3] estimates there are approximately 50 trawlers with freezers on the Tortugas grounds during the season.

Approximately 20% of the shrimp from the Tortugas grounds that are landed in the Key West area have heads on. Much of this shrimp is headed at the dock, while a portion is marketed to retail outlets, heads on. This heads-on retail market is said to be lucrative due to the price received for the shrimp and the fact that little expense is involved in handling. Typically, the shrimp are sorted from the fish, put in bags up to 60 lbs and frozen, heads on. This product entails very little handling and can be distributed to various users along the coast. Vessels operating out of Marathon are typically freezer vessels and land their entire catch heads on.

The Tortugas fishing grounds have been described by Iversen et al. (1960). In 1960, fishing was concentrated in statistical subarea 2. These authors indicated that shrimp occur outside the regularly fished area but fishing is difficult and hazardous because of the presence of loggerhead sponges, coral and other obstructions. They clearly indicated that small clear areas are found outside the region and these are occasionally trawled with the aid of lighted buoys set out by the fishermen.

RESULTS

In reviewing the catch by statistical areas from 1960 through 1981, it is apparent that the fishery was concentrated in what is referred to as statistical subarea 2 from 1960 to approximately 1972 (Fig 2). Thereafter, the fishing grounds appear to increase considerably, with more effort exerted in statistical subarea 3 from 1972 to the

present and by 1980, statistical subarea 1 became slightly more important. Therefore, the grounds have expanded in nature from the inception of the fishery to include areas further to the north and south of Key West. The reason for this expansion is that continued trawling cleared the grounds of loggerhead sponge and coral. In fact, in 1981, almost 3⅓ milliom lbs of shrimp were landed from statistical subarea 3 whereas in 1960, only about 10,000 lbs were landed from this subarea.

1981 Fishery Locations

In 1981, the Tortugas pink shrimp fishery was located in three statistical subareas (1, 2 and 3). Landings from these subareas by depth zones are shown in Figs 3a-3l. Note that the majority of the catch was caught in statistical subarea 2 in January in depth zones 11-15 and 16-20 fms. A small amount of catch was also produced in the 11-15 fm depth range in subarea 3. The February catch was much less and was distributed in approximately the same areas as January. In March, large catches were produced in all three statistical subareas, with the predominant catch being found in the 6-10 fm depth range in subareas 1 and 3, with the next peak in subarea 2 in 11-15 fms. April landings were also large; however, catches were made mostly in statistical subarea 2 in the 11-20 fm depth ranges and some catch was produced in subarea 3 in the 11-20 fm depth range. A similar pattern existed in May and June but with lower catches. No catches were made in subarea 1 after June. In July, August and September, catches were concentrated in subarea 2 in the 11-15 fm depth range and continued to be low. In October, catches increased in subarea 2 and by November and December the catches were very high in subarea 2 in the 11-15 fm depth zone.

Landings

Annually, landings in statistical subareas 1 through 3 from 1960-1981 have averaged approximately 10 million lbs/yr (Fig 4). They have fluctuated from a high of slightly more than 14 million lbs in 1960 to a low of about 7 million lbs in 1972. The peak annual production occurred in 1981, with landings of almost 14.5 million lbs of pink shrimp. The small variation in annual landings, depicted by the standard deviation of ±1.6 million lbs, indicates a relatively stable fishery throughout the 21-yr period. Note also that there are only five years (1960, 1963, 1972, 1975 and 1981) in which landings fell outside one standard deviation from the mean.

The avearge monthly landings for 1960-1979 showed an annual cycle whose amplitidue ranged from a high of 1.4 million lbs in January to a low of 260,000 lbs in July. Average monthly landings from 1960-1980 were high in January, decreased considerably in February, rose slightly in March and decreased steadily to the low in July (Fig 5). Values increased very slightly in August, again in September and substantially in both October and November. December's value was about the same as November's, both being about the same as March's. It appears evident that the historical fishery is based on recruits entering the fishery in September-October and providing the supply for this fishery through March-April.

In 1981, the monthly pattern of shrimp landings with regard to magnitude was significantly different from the historical record for 1960-1980 (Fig 6). Landings were greater in January and significantly greater from March through September. We examined these data by 2-way ANOVA which clearly showed there were significant differences between years and between months (Table 2). We then grouped

the data into average monthly landings for 1960-1980 and made comparisons with the 1981 monthly landings by paired t-tests. These results indicated that 1981 was significantly different from the historical data set (t_{11} = 3.974*). In addition, we were interested to know if there was any difference in the average monthly landings between 1981 and the last five years in the fishery and the first five years for which we have statistical records. As a result, we conducted paired t-tests between the historical years (1960-1964) versus 1981 and between 1976-1980 and 1981. These tests indicated that there were significant differences between these two historical data sets and 1981 (1960-1964, $t_{(11)}$ = 2.456** and 1975-1979, $t_{(11)}$ = 3.956***). In addition, the SNK test indicated most annual landings were equivalent within statistical measures (Table 3). We also examined the average landings by month, utilizing the SNK test since the ANOVA indicated differences between months. These results indicated that through the years the landings were similar in the following pairs of months: July and August, June and September and May and October and these sequences of months were different from the remaining months. Therefore, further analyses using landings data may be grouped into these pairings (Fig 7, Table 4).

Fishing Effort

Fishing effort (1960-1981)**** averaged approximately 16.5 thousand days/yr with a standard deviation of ±1.6 thousand days. Highest effort was expended in 1961 and

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*Significant at 99% level.

**Significant at 95% level.

***Significant at 99% level.

****1980 effort data were not used because it is not available in final form.

again in 1978. Lowest effort was expended in 1971 and 1972. Effort did not fluctuate greatly throughout the 20-yr period in this fishery and remained fairly constant with some low efforts in 1971 and 1972, with no sequence of years having a high level of effort (Fig 8). The average appears to be a good indicator of the constancy of this fishery. In 1981, the effort was a little below average.

The average monthly efforts expended in statistical subareas 1-3 (combined) for the period 1960-1979 (Fig 9) generally follow the same pattern of highs and lows as the average monthly landings for the same time span. The fishing effort was generally low in July, August and September. It increased steadily through the fall months to a peak in January. Effort remained high in February and March before declining in April, May, June and July. The monthly fishing effort expended in 1981 (Fig 10) was somewhat different from the historical trend but only slightly so. The monthly fishing efforts for February and December 1981 were more than one standard deviation below the means for the corresponding months' efforts for the historical data set. Efforts in April, June, July and September 1981 were more than one standard deviation above the means from the corresponding months for the historical data set. The rest of the monthly fishing effort data set appears to be similar to the historical data set, indicating that fishing effort in all months except February and December were similar to the historical fishing effort.

Relative Abundance

The relative abundance of pink shrimp is measured by the CPUE for 24-hr fishing day and it is remarkably stable throughout the 1960-1979 period, with an average of 603 lbs/24-hr day with a standard deviation of $\pm$63 lbs/24-hr day for this time span (Fig 11). The highest CPUE was in 1960

and 1981. In 1960, the CPUE was approximately 751 lbs/24 hrs whereas in 1981, the CPUE (959 lbs/23 hrs) was significantly greater than CPUE estimates for the previous 20-yr period.

The average monthly CPUE for pink shrimp for 1960-1979 is remarkably stable from January through August. During these months, the CPUE averaged between 500 and 600 lbs/24-hr day (Fig 12). The CPUE increased appreciably in September, increased to a peak in October and dropped to slightly below the September value in November. A large amount of variation is noted in the September and October CPUE figures. This variation is probably attributable to the variability in recruitment between years, as the major recruitment of the fishery normally occurs in September and October.

The CPUE or measure of relative abundance in 1981 appears to be greater than the historical average noted in March, April and May (Fig 13). Lower CPUE was noted only in the month of November.

In analyzing the CPUE by months and between years, we ran a 2-way ANOVA that indicated there was a significant difference between years and months (Tale 5). We further analyzed the data by paired t-tests in comparison with the historical average CPUE for 1960-1979 versus 1981, the first five years of the fishery (1960-1964) versus 1981 and the last five years for which we have data (1975-1979) versus 1981. The results of these tests show there were significant differences between all comparisons (Table 5). Thus the relative abundance estimates on the Tortugas shrimp grounds was significantly greater in 1981 than in the 1960-1964 or 1975-1979 time frames.

We further analyzed the average CPUE for the 21-yr period utilizing the SNK test. These results indicated a

great amount of similarity between the average CPUE between years and identified two nonsignificant groupings of years (Table 6). The average CPUE by month was also analyzed using the SNK test, which revealed five subsets of similar months (Table 6).

Size

We inspected the percent size distribution of the commercial pink shrimp landings by month in 1981 (Fig 14a-14l). In January, the predominant size distribution was 41-50 count shrimp with approximately equal quantities in all the large size categories. In February, there did not appear to be any single dominant size group, the most frequent size classes were 21-25, 31-40 and 51-67 count shrimp. In March, there were two dominant peaks at 68-count or smaller and 51-67 count with almost no other size category being of importance to the fishery. In April, the same phenomenon was observed with two major peaks, one at 51-67 count and one at 68-count or smaller. The same sequence occurred in May, with those two dominant peaks and by June the dominant peak was 51-67 count with the other size classes still not being important. In September and October 1981, we noted a slight peak at the 51-67 count level but in October, there was a tri-modal peak ranging from 31-40 to 51-67 count and in November, no single size class dominated the catch. In December, 31-40 count shrimp dominated the catch.

We compared the differences between the 1981 percent size class distribution and the historical size class distributions for the 1960-1964 and 1976-1980 time frames, utilizing a G-test (Table 7). The results indicated there were significant size differences in the composition of the landings for all months between the 1960-1964 time frame, the 1976-1980 time frame and the 1981 values. There were also significant differences in size composition for all

months except February and September, when 1976-1980 averages were tested against 1981 values.

The major differences between the 1981 size composition and the historical size composition data is that in 1981, large catches of small pink shrimp (51-67 count and 68-count or smaller) were caught in March, April, May and June whereas the 1976-1980 period did not indicate those dominant modal groups in those months. The historical size composition data also showed dominant modal groups of small shrimp in September and October, whereas the 1981 data did not show as dominant modal groups of small shrimp. This finding indicates major shrimp recruitment in the spring of 1981 and some recruitment in the fall. The size composition in October-December 1981 is significantly different in composition from the last five years of the fishery (1976-1980); the difference is that the 1981 landings are large in size.

Catch and Fishing Effort

We have examined the landings in millions of lbs versus total projected days fished for the time frame 1960-1981, omitting 1980 data. Two years were very different than the others - 1960 and 1981 (Fig 15). The relationship shows considerable stability in the fishery, which centers around 15-18 thousand days fished with catches ranging from approximately 8 million lbs to slightly more than 11 million lbs/yr. These values encompass most of the years examined in this graph.

Low catch and effort were experienced in 1971 and 1972 and high catch and relatively high effort were experienced in 1960; low catch and a high level of effort were observed in 1961. In 1981, catches were high and effort low - very different than any other years in the fishery.

DISCUSSION

The permanent Tortugas sanctuary was established in May 1981. In trying to evaluate the management regulations, we have specifically looked at landings, effort, CPUE and size composition from May through December 1981 and have compared these catch statistics with the historical data from 1960-1979.

Monthly landings in 1981 were higher in May, June, July, August and September and lower in October, November and December when compared with average landings in corresponding months from 1960-1980. In comparing the monthly relative abundance from May-December between 1981 and the historical record, it is evident the CPUE was significantly greater from May-October and December and lower in November 1981 from the historical data. In comparing the size composition between 1981 and 1976-1980, it appears there are significant differences for all months from May-December except September. The 1981 data clearly indicates a dominant modal group from March-August. This modal group is apparently the strong spring year class than entered the fishery in March, April and May and continued to grow to a 31-40 count by August. Historically, this modal group was not evident in the first five years nor was it evident in the last five years of the fishery. The September 1981 size class data were not significantly different from the September data for 1976-1980. There appeared to be a similar amount of recruitment in September 1981 and September 1976-1980. The October size frequency distributions, however, were startlingly different in that the historical data reflected strong recruitment in both October and November, whereas the 1981 data did not reflect such recruitment.

There were large differences in the landings, CPUE and, to a degree, the size composition on the fishing grounds from May-December 1981 compared with previous years. However, it is not possible to make a determination from these data that those differences were attributed to implementation of the Tortugas sanctuary. The reason we came to this conclusion is that there was a major recruitment into the Tortugas shrimp fishery in March and April, which preceded implementation of the line. However, we speculate that the line may have contributed to the continued high CPUE and high landings as well as preservation of the dominant modal group that was recruited into the fishery in March and April and resulted in slightly larger shrimp being harvested from October-December 1981.

Questions also arise as to how many fishermen refrained from fishing inside the sanctuary, as 33 violations were documented from May 1981 through March 1982 (Fuss).[4] If considerable amounts of illegal fishing did occur, the catch results presented in this paper may be biased in terms of measures of CPUE. Further, the full benefits of the sanctuary would not be realized.

SUMMARY

Commercial landings from statistical subareas 1, 2 and 3 in 1981 greatly exceeded landings in all years of the fishery since 1960. Average landings are approximately 10 million lbs/yr; however, in 1981 landings amounted to 14.5

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[4]Fuss, Charles; DOC/NOA/NMFS/SERO, St. Petersburg, FL; personal communication.

million lbs of shrimp. The landings appeared to be stable during the 21-yr period, with the exceptions of 1960-1962, 1972, 1975 and 1981, which fell outside the standard deviation of this 21-yr period.

The fishery basically begins each year in September/ October with recruitment of small shrimp to the grounds. Peak production is in December, January and February and is followed with a slight decline in March and April production, tapering off considerably in the May-August period. Monthly landings differed significantly from March through September 1981 from the same months for all other years of the fishery.

Fishing effort did not fluctuate greatly over the 20-yr period and averaged 16.5 thousand days/yr. Highest effort was expended in 1961 and again in 1978. In 1981, the effort was a little below average but within one standard deviation for the 20-yr period.

There were significant differences in the CPUE between 1981 and all other years in the fishery. The relative abundance of pink shrimp, as measured by CPUE for 24-hr fishing days, is remarkably stable throughout the 1960-1979 period with an average of 603 lbs/24-hr day. The highest CPUE occurred in 1981 with a catch of 957 lbs/24-hr day. Further, when comparing fishing effort versus catch, the fishery appears to be remarkably stable for all years except 1981.

Size distribution in 1981 was sigificantly different from the last five years (1976-1980) and the first five years (1960-1964) of the fishery. The primary difference was a large recruitment of 50-count or smaller shrimp into the Tortugas fishing grounds in March and April. This recruitment could be followed by their modal size classes through August. Historically, there is not a large spring

recruitment; however, 1981 was different and this spring recruitemnt was easily detectable in the size categories of the commercial landings. Also, the size of shrimp landed in October-December 1981 was larger than for previous years.

The catch and relative abundance, as well as the size distribution of the shrimp on the Tortugas grounds, was different in 1981 than in all other years of the fishery except perhaps 1960. Landings were higher, CPUE was higher and major recruitment of small shrimp, which could be followed throughout the fishery for several months, occurred in March and April. Establishing the sanctuary line may have protected the small shrimp which were in the area during the months of May-September, however we cannot make that determination at this time. In 1981, the usual fall recruitment probably was not as great as in previous years.

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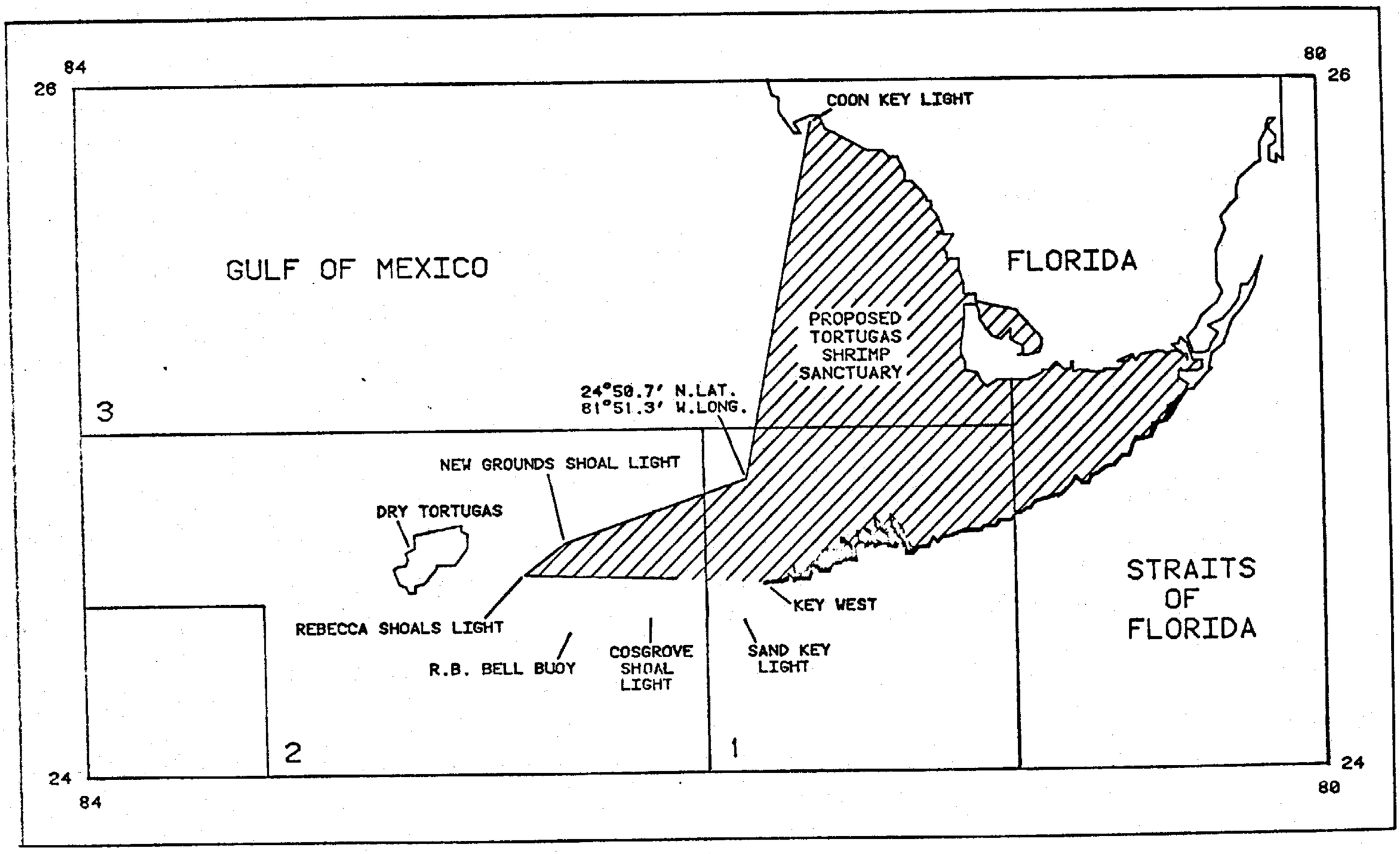

Figure 1. Chart of Dry Tortugas fishing grounds and statistical subareas.

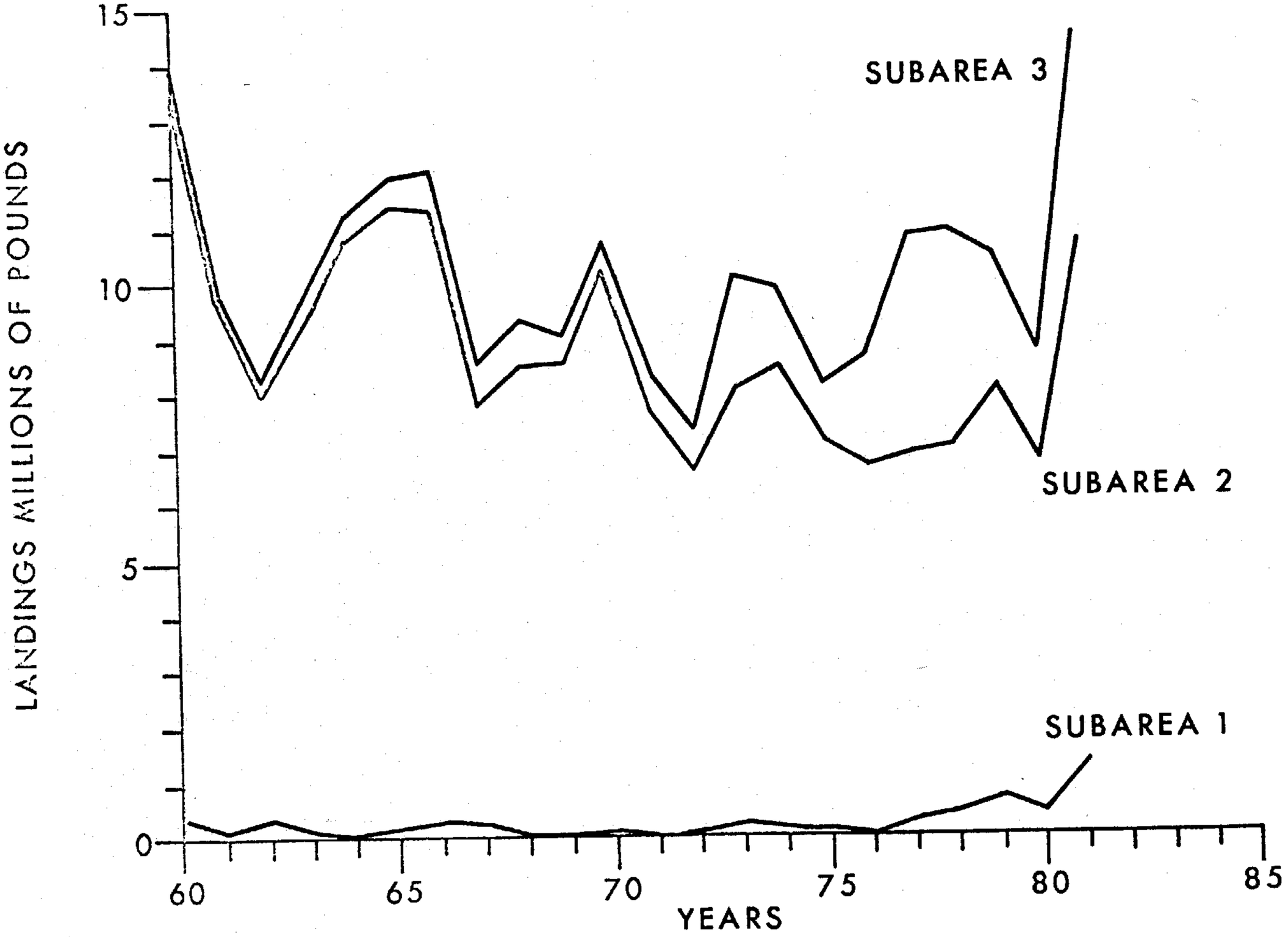

Figure 2. Cumulative landings of pink shrimp in millions of pounds from statistical subareas 1, 2 and 3 by years.

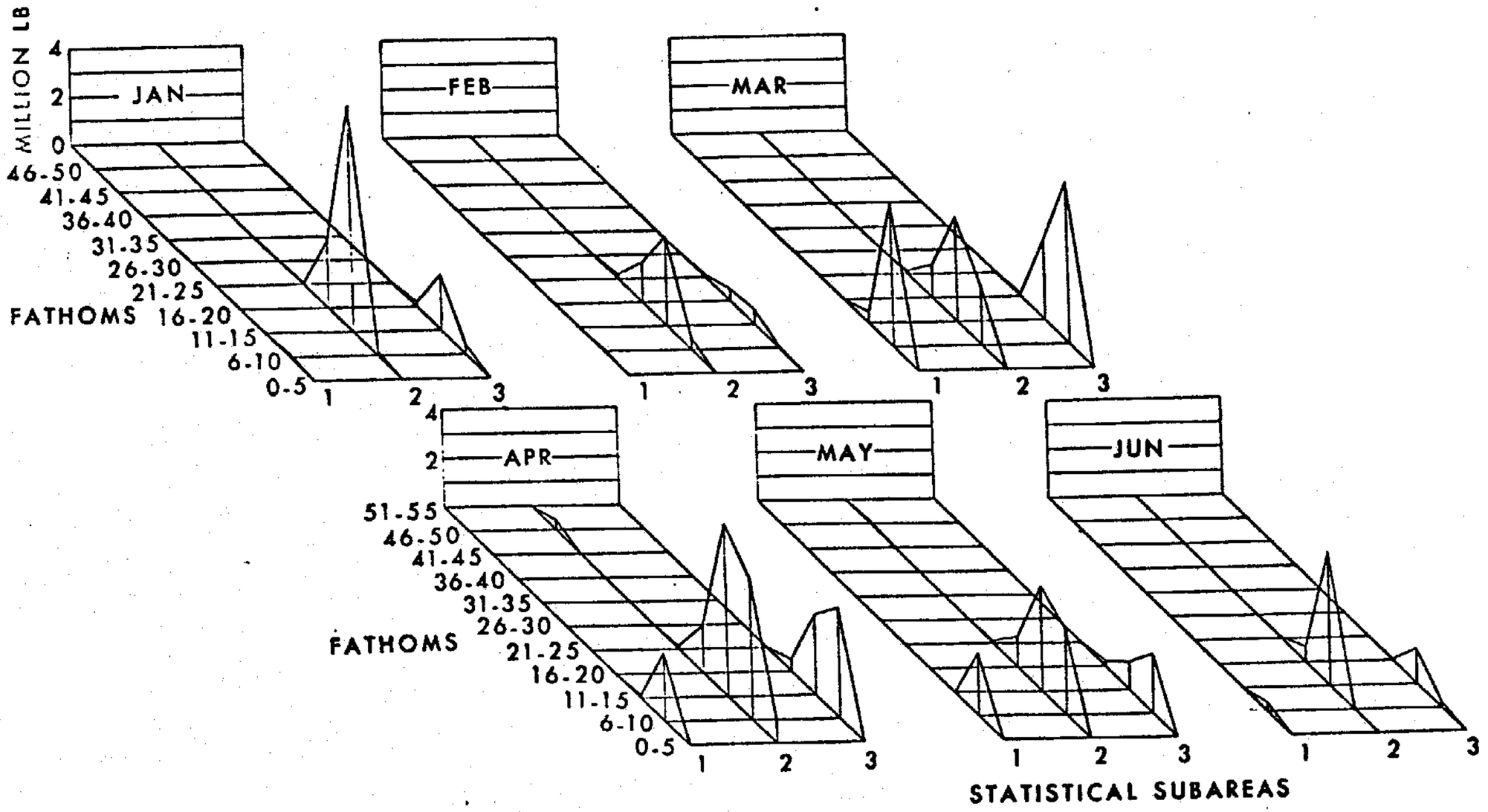

Figure 3. Landings of pink shrimp by month in 1981 by depth zones in statistical subareas 1, 2 and 3.
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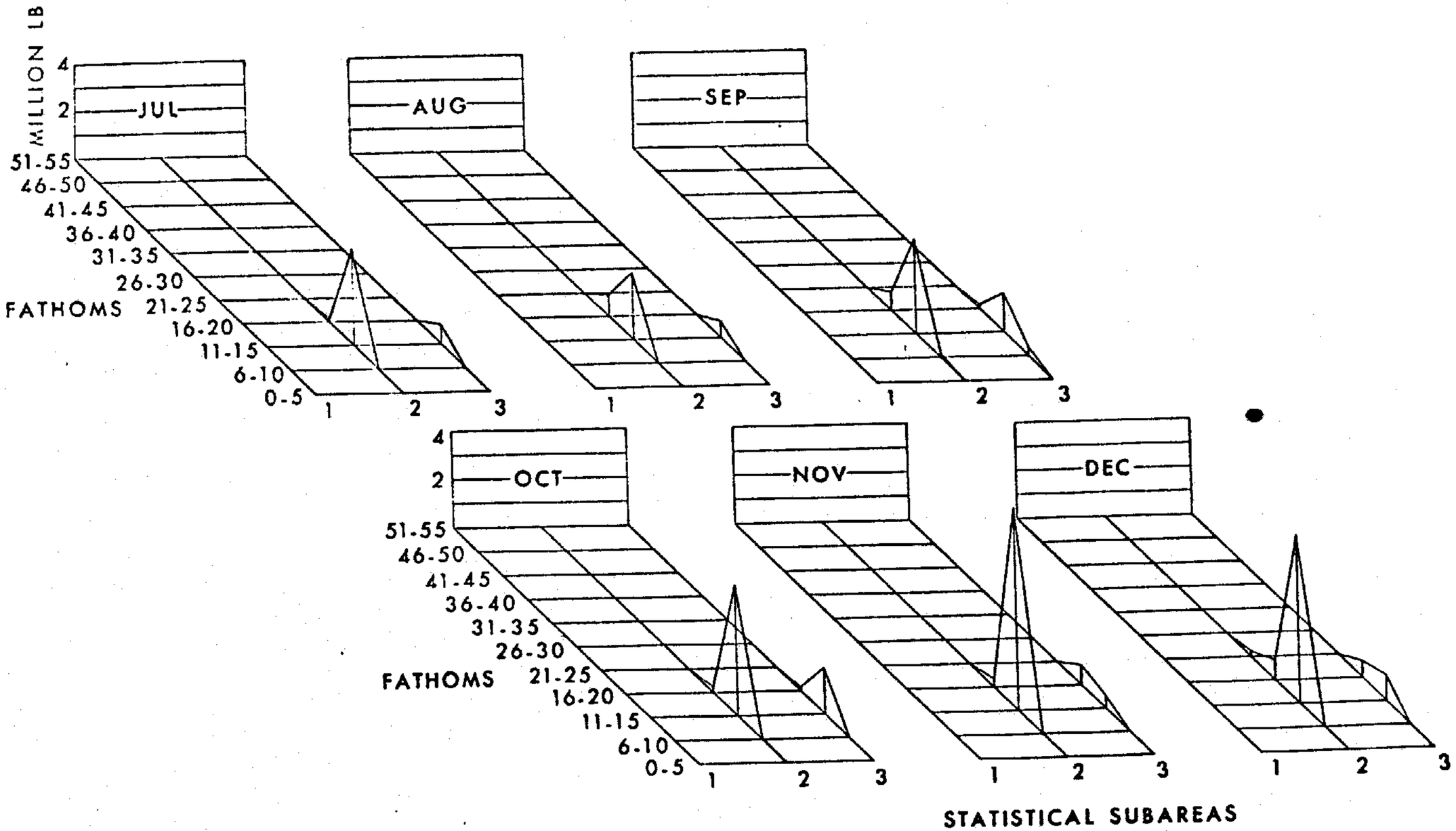

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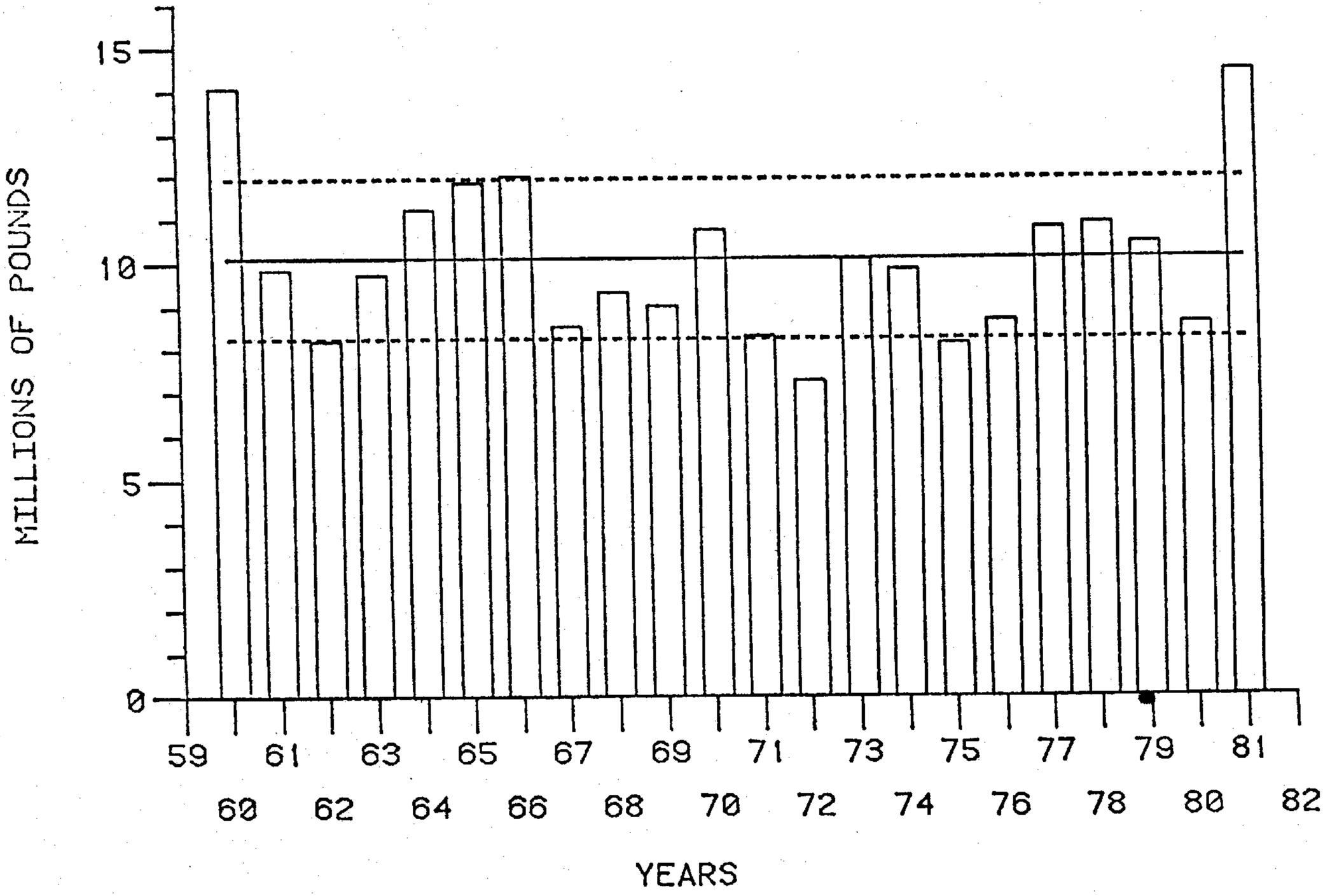

Figure 4. Annual shrimp landings in millions of pounds from statistical subareas 1, 2 and 3, 1960-1981 (solid line is average landings; broken line is one standard deviation).

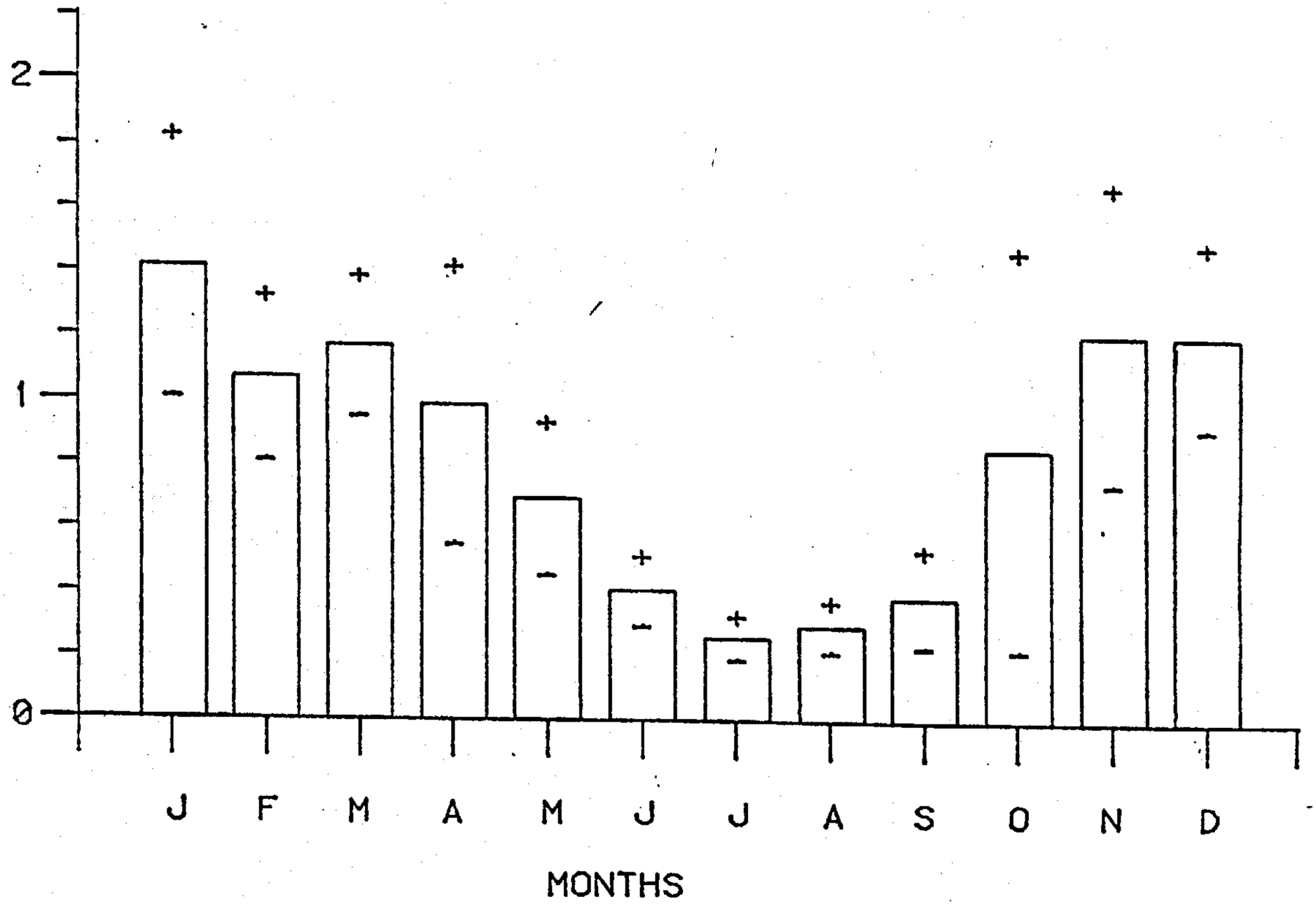

Figure 5. Average monthly pink shrimp landings in millions of pounds, 1960-1979, from statistical subareas 1, 2 and 3, ±one standard deviation.

1, 2 and 3, ±one standard deviation.

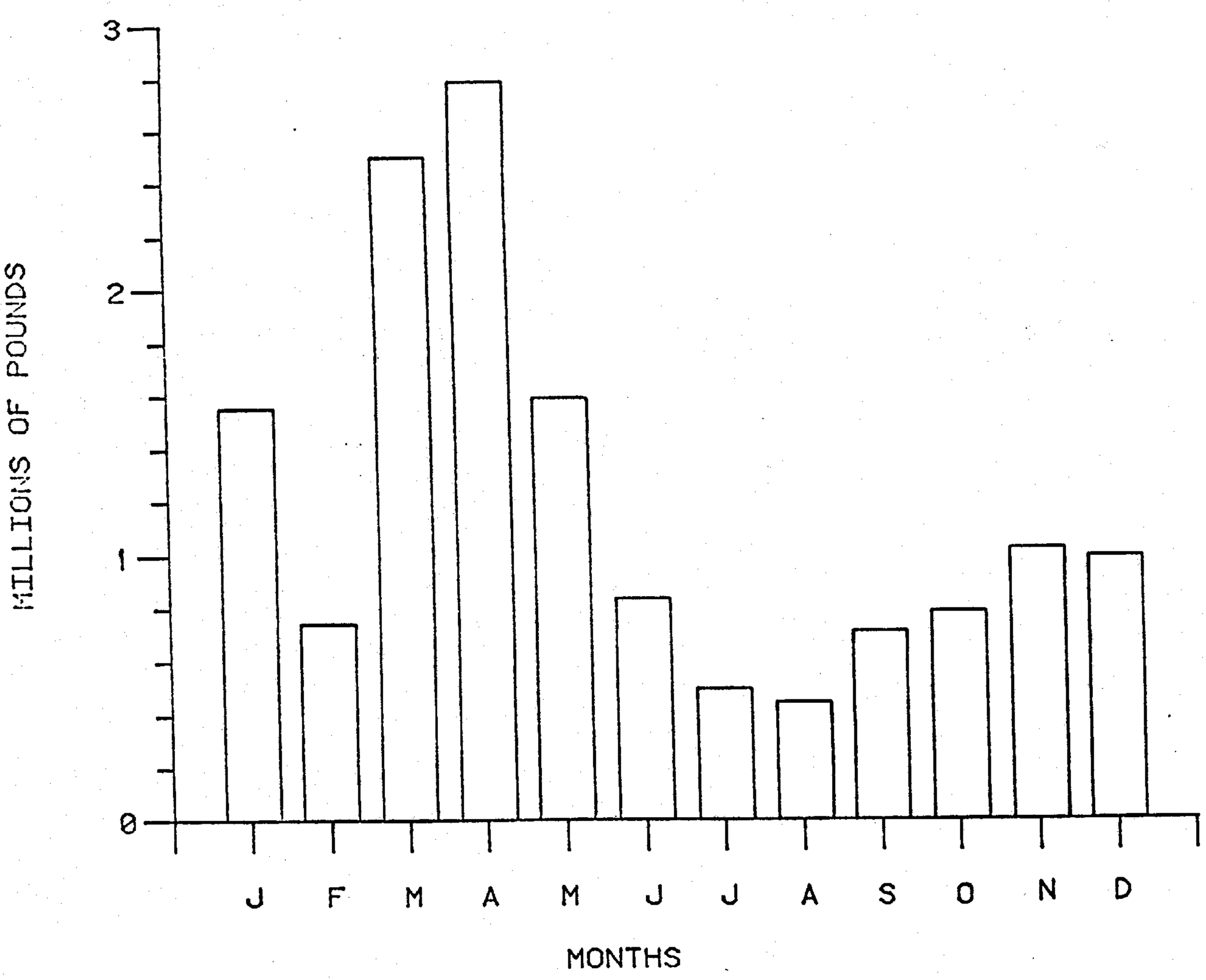

Figure 6. Monthly pink shrimp landings in millions of pounds in 1981 from statistical subareas 1, 2 and 3.

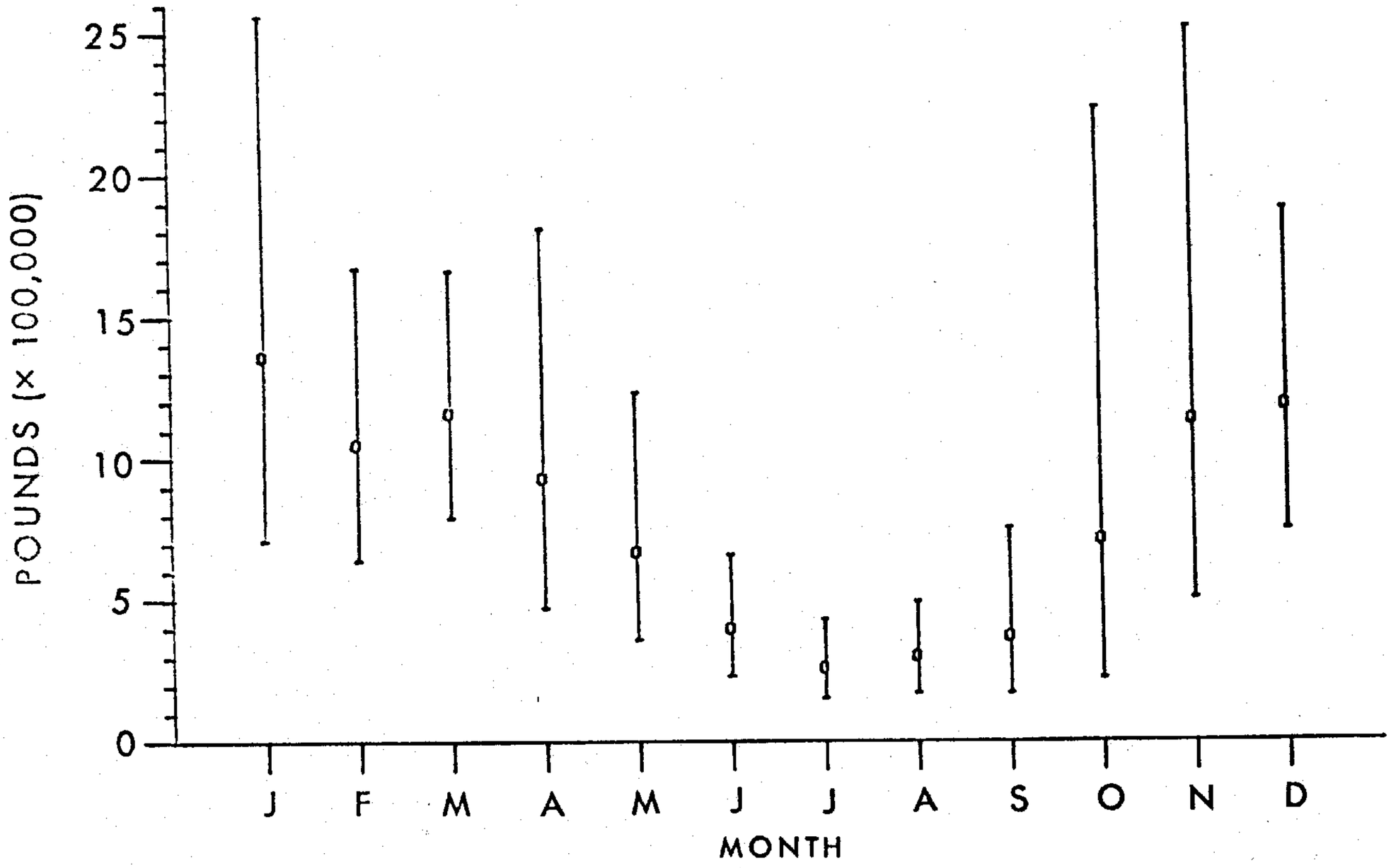

Figure 7. Average monthly landings of pink shrimp in statistical subareas 1, 2 and 3. The vertical line represents the 95% confidence interval.

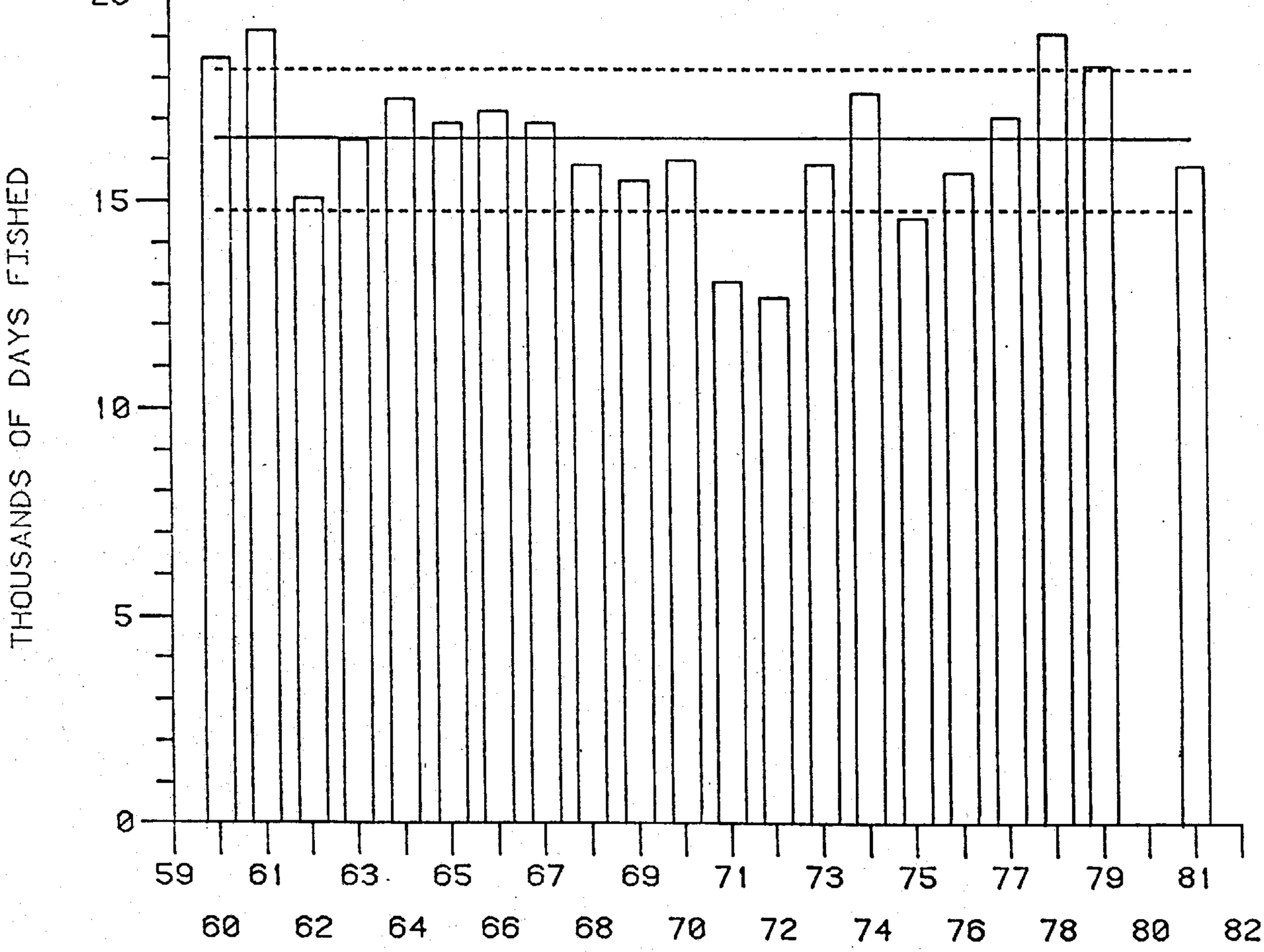

Figure 8. Fishing effort in thousands of days fished by year from 1960-1979 and 1981 (solid line is average effort and broken line is one standard deviation).

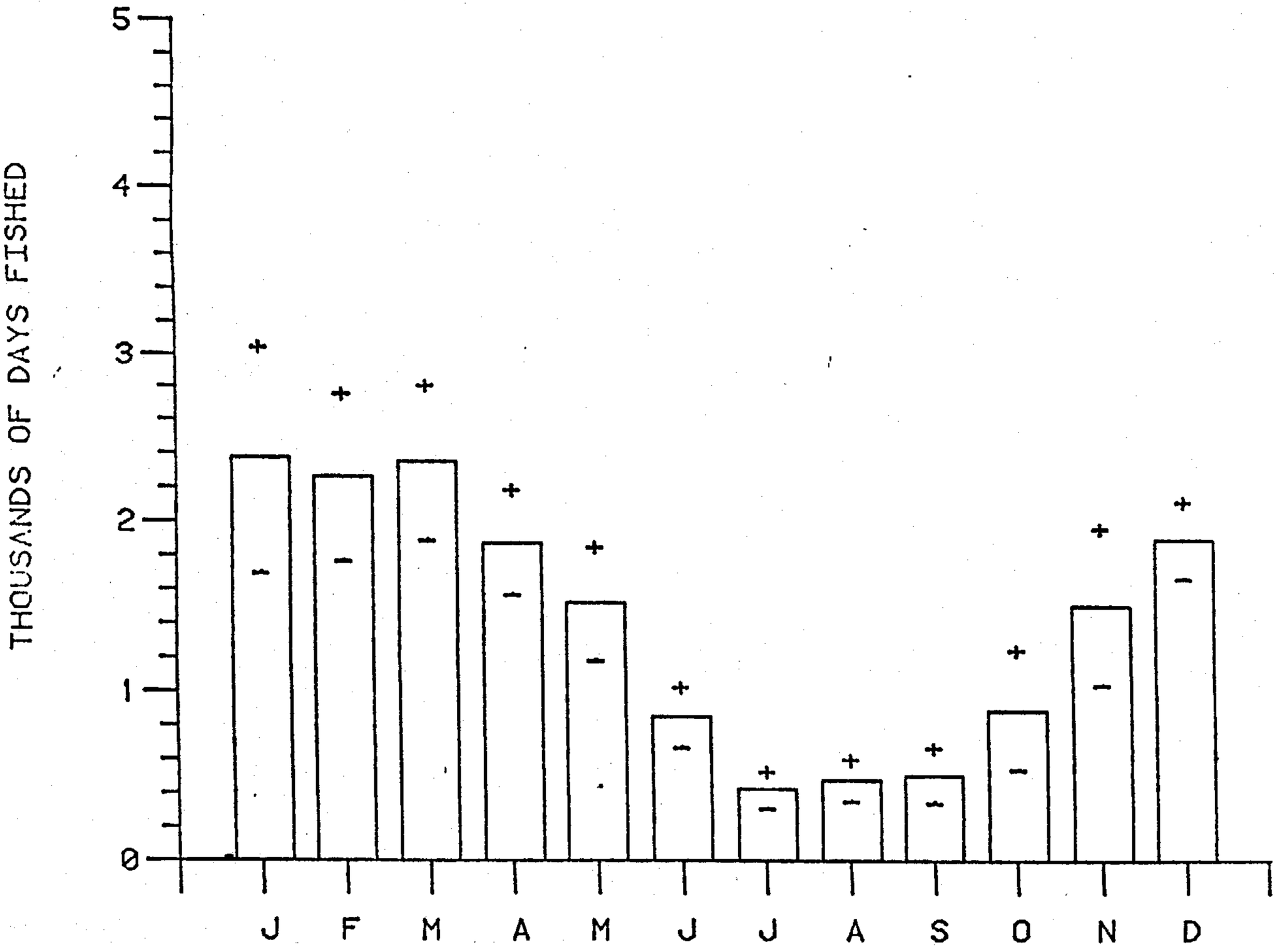

Figure 9. Average monthly pink shrimp fishing effort, 1960-1979, for statistical subareas 1, 2 and 3, ±one standard deviation.

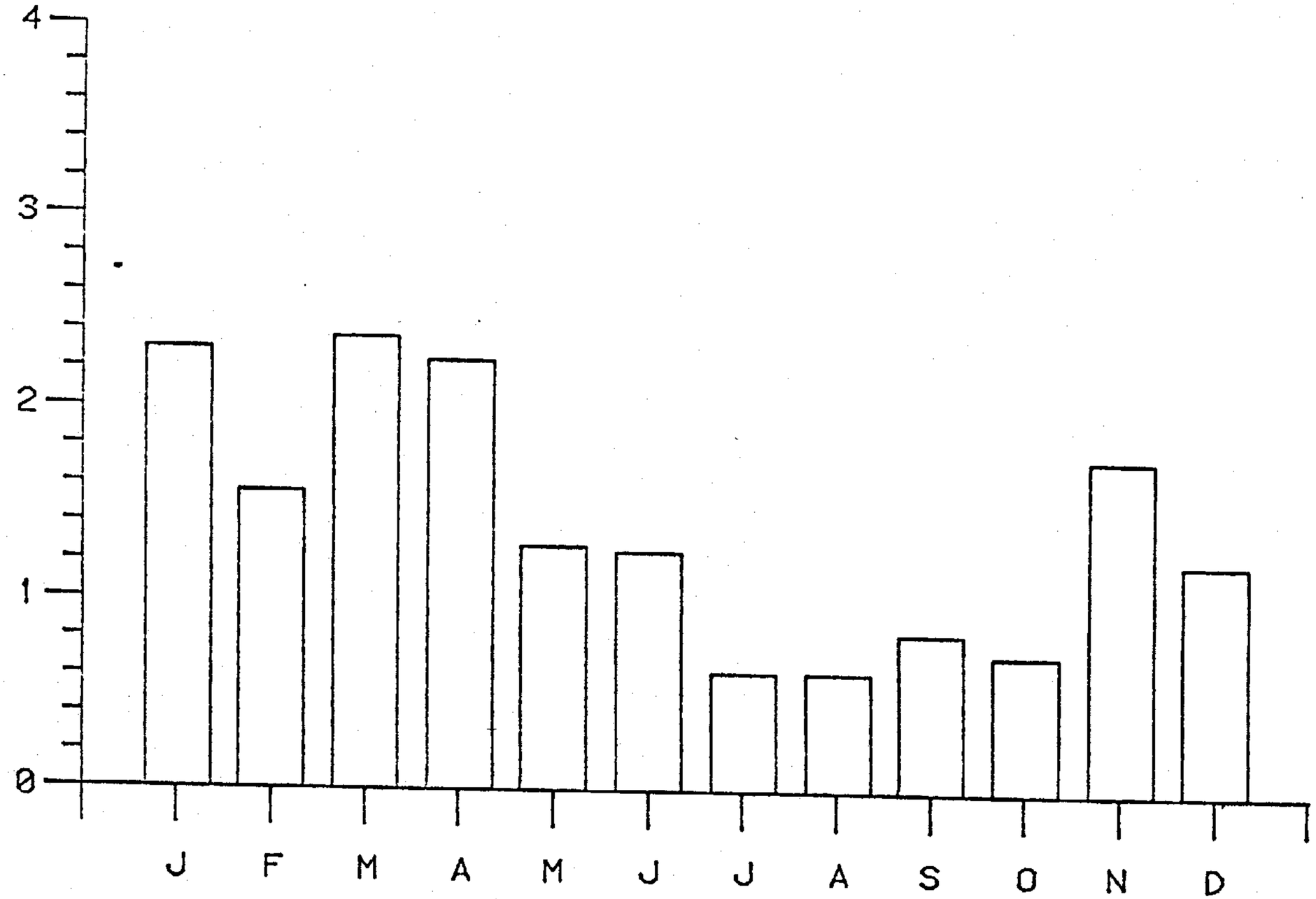

Figure 10. Average monthly pink shrimp fishing effort, 1981, for statistical subareas 1, 2 and 3.

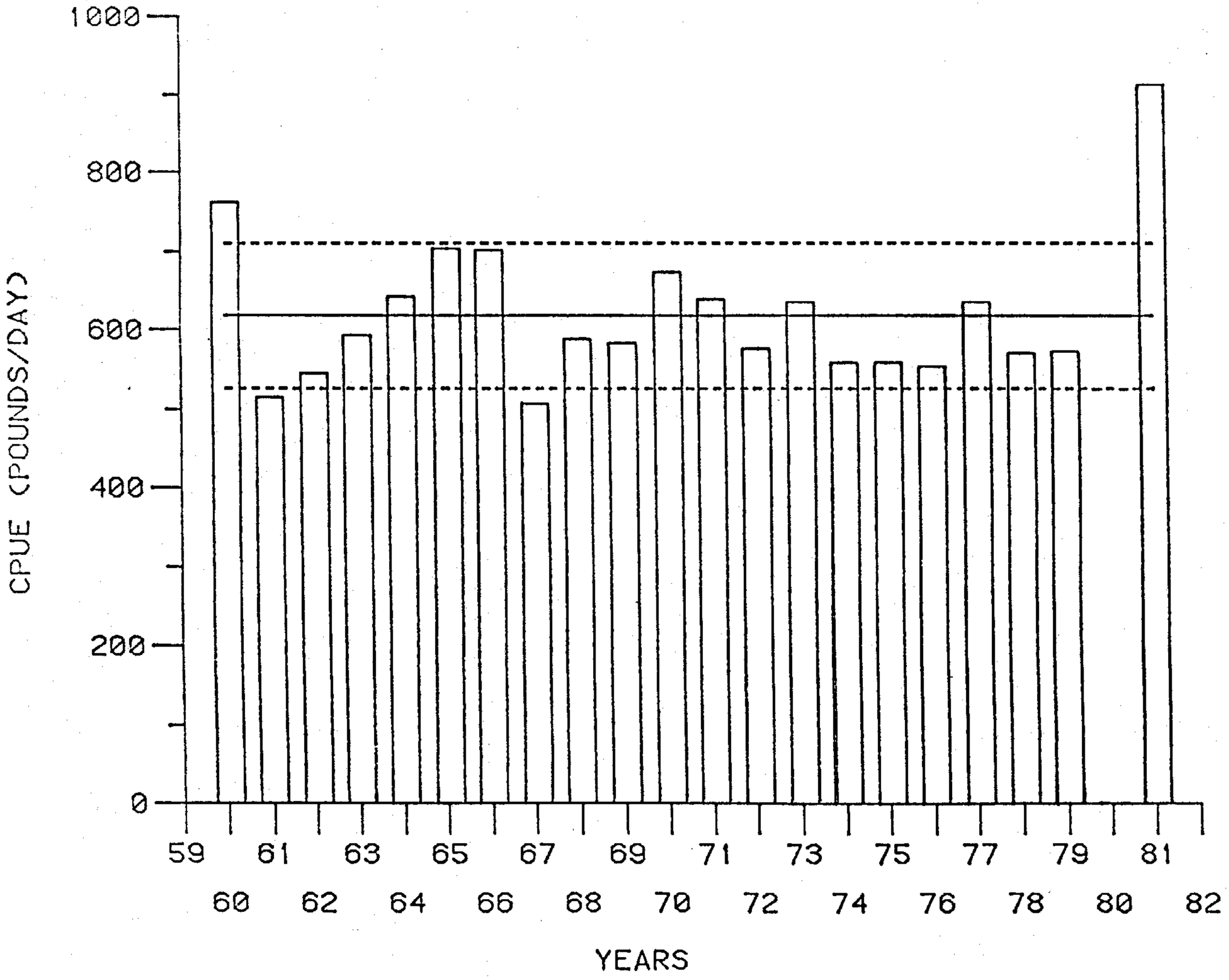

Figure 11. Catch per unit effort from 1960-1979 and 1981 in statistical subareas 1, 2 and 3 (solid line is average, broken line is one standard deviation).

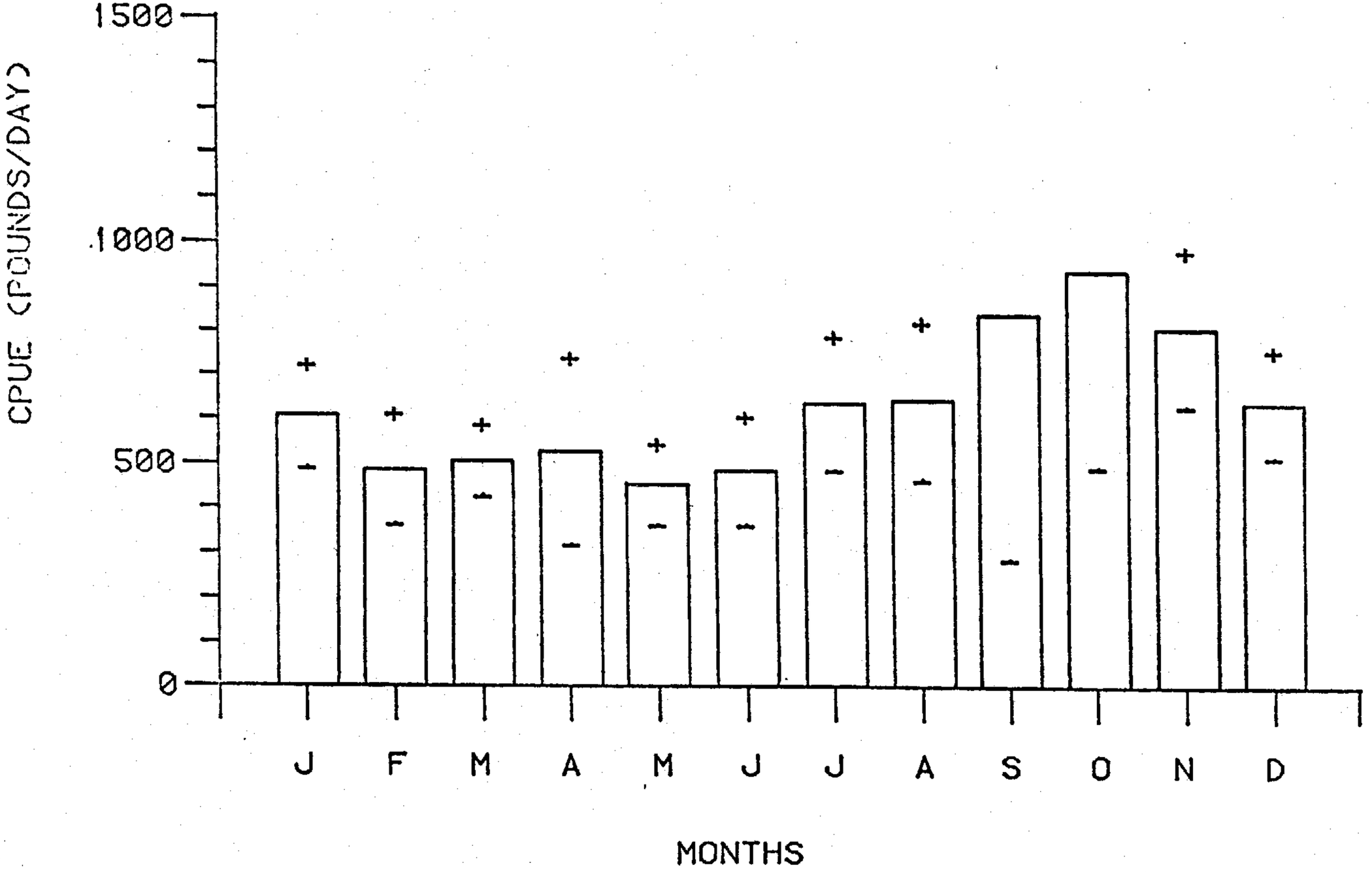

Figure 12. Average monthly pink shrimp CPUE, 1960-1979, from statistical subareas 1, 2 and 3.

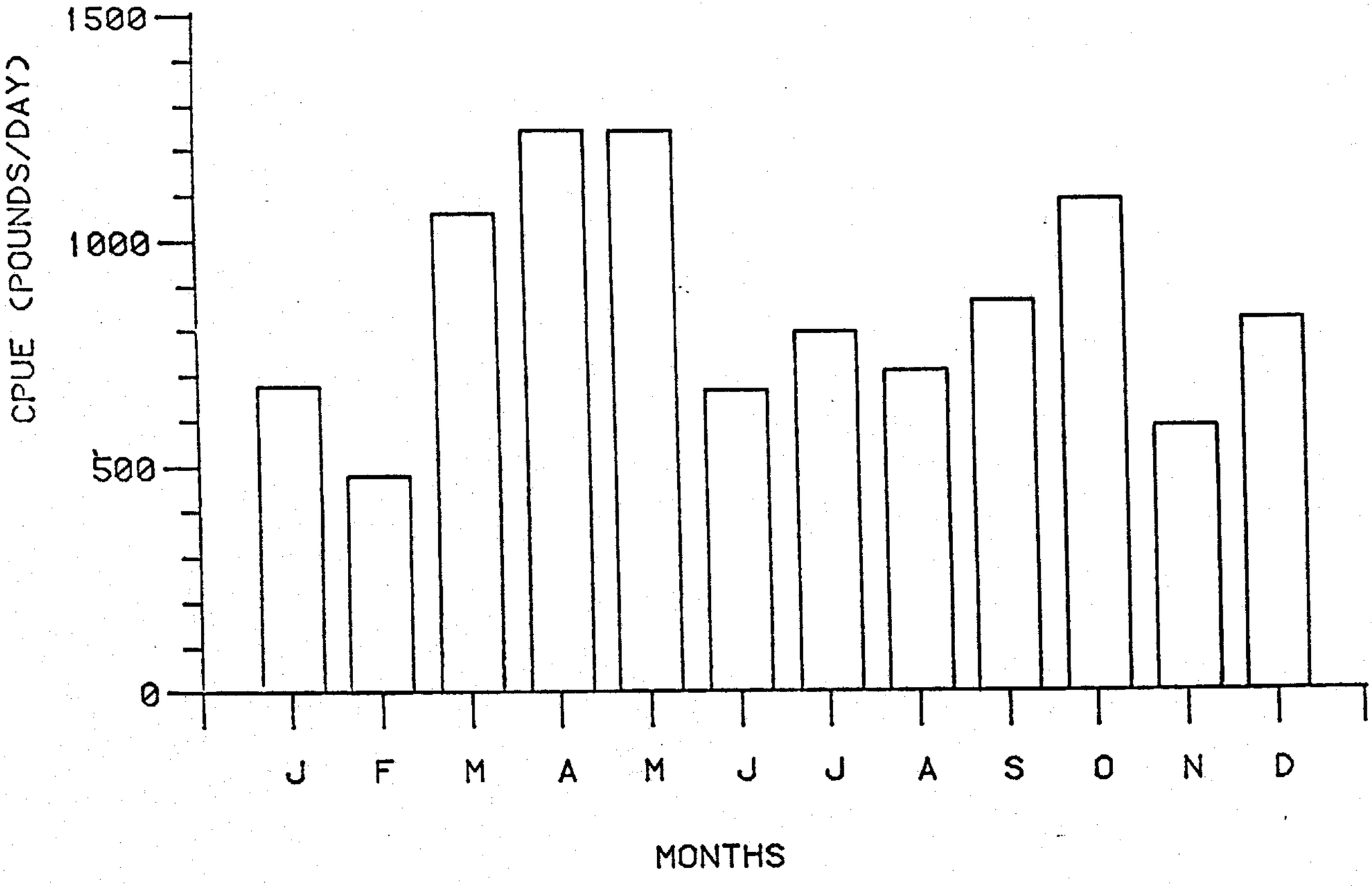

Figure 13. Monthly pink shrimp CPUE in 1981 in statistical subareas 1, 2 and 3.

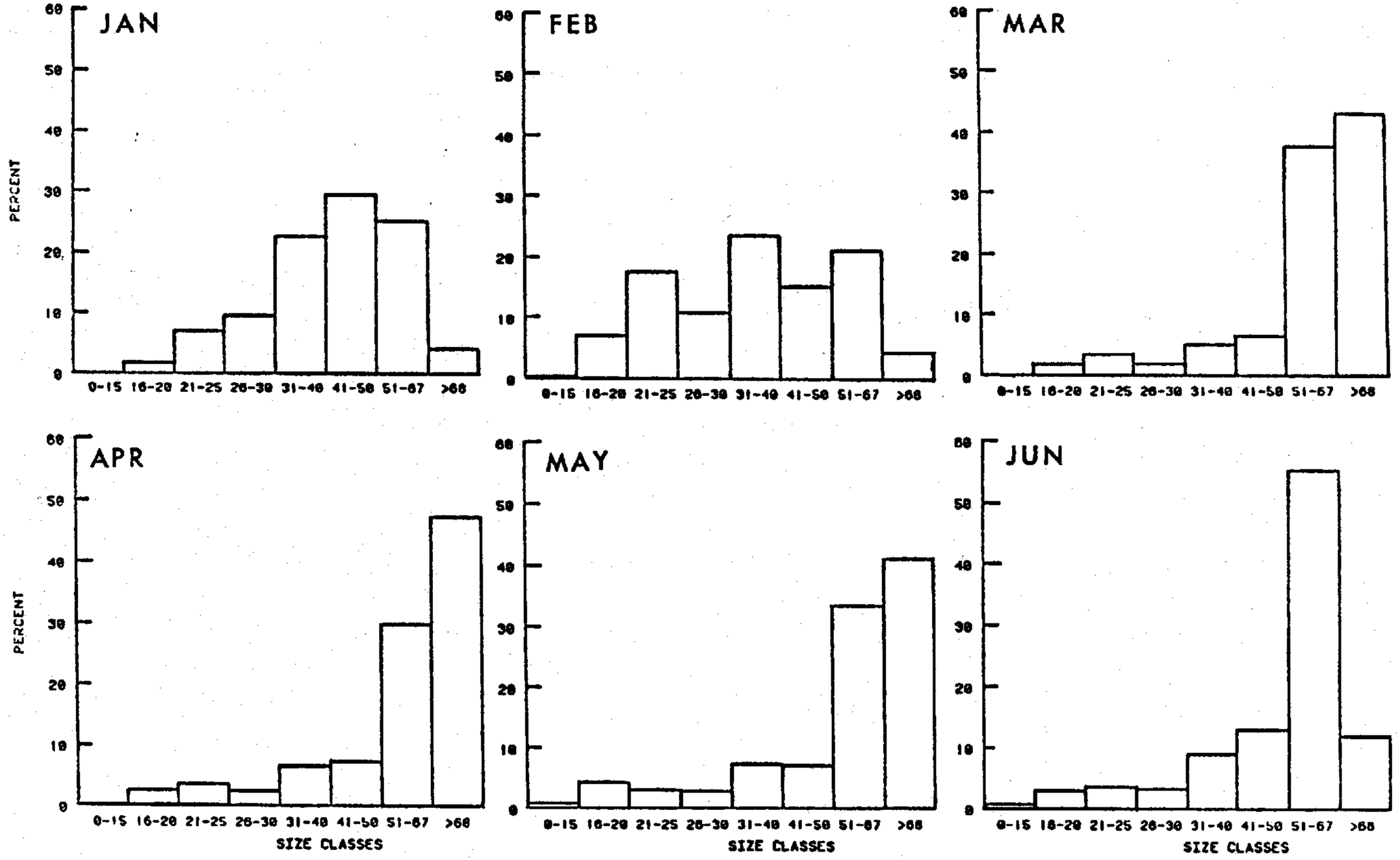

Figure 14. Percentage composition of pink shrimp by size class by month in 1981 from statistical subareas 1, 2 and 3.
14a-14f

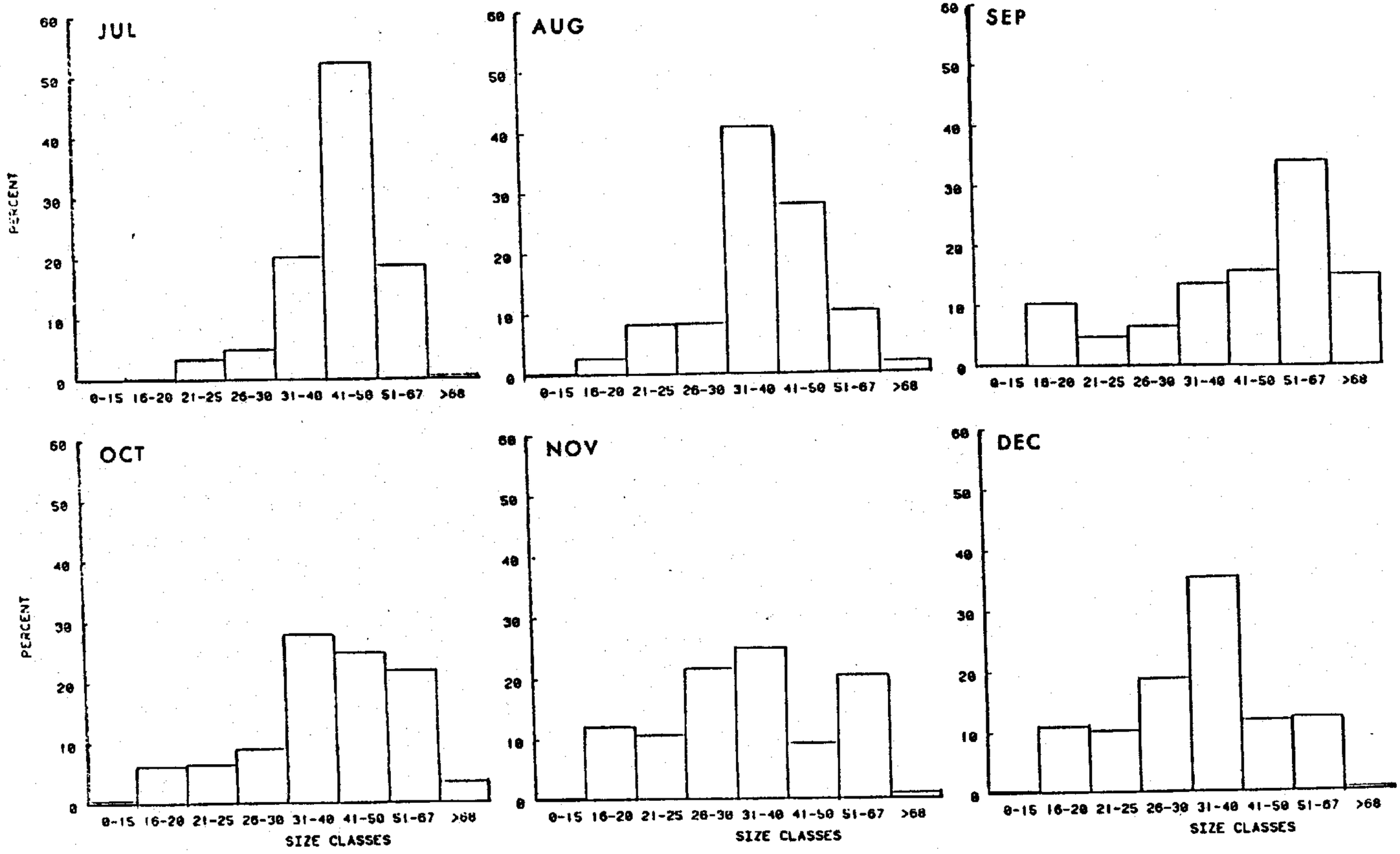

Figure 14. Percentage composition of pink shrimp by size class by month in 1981 from statistical subareas 1, 2 and 3.

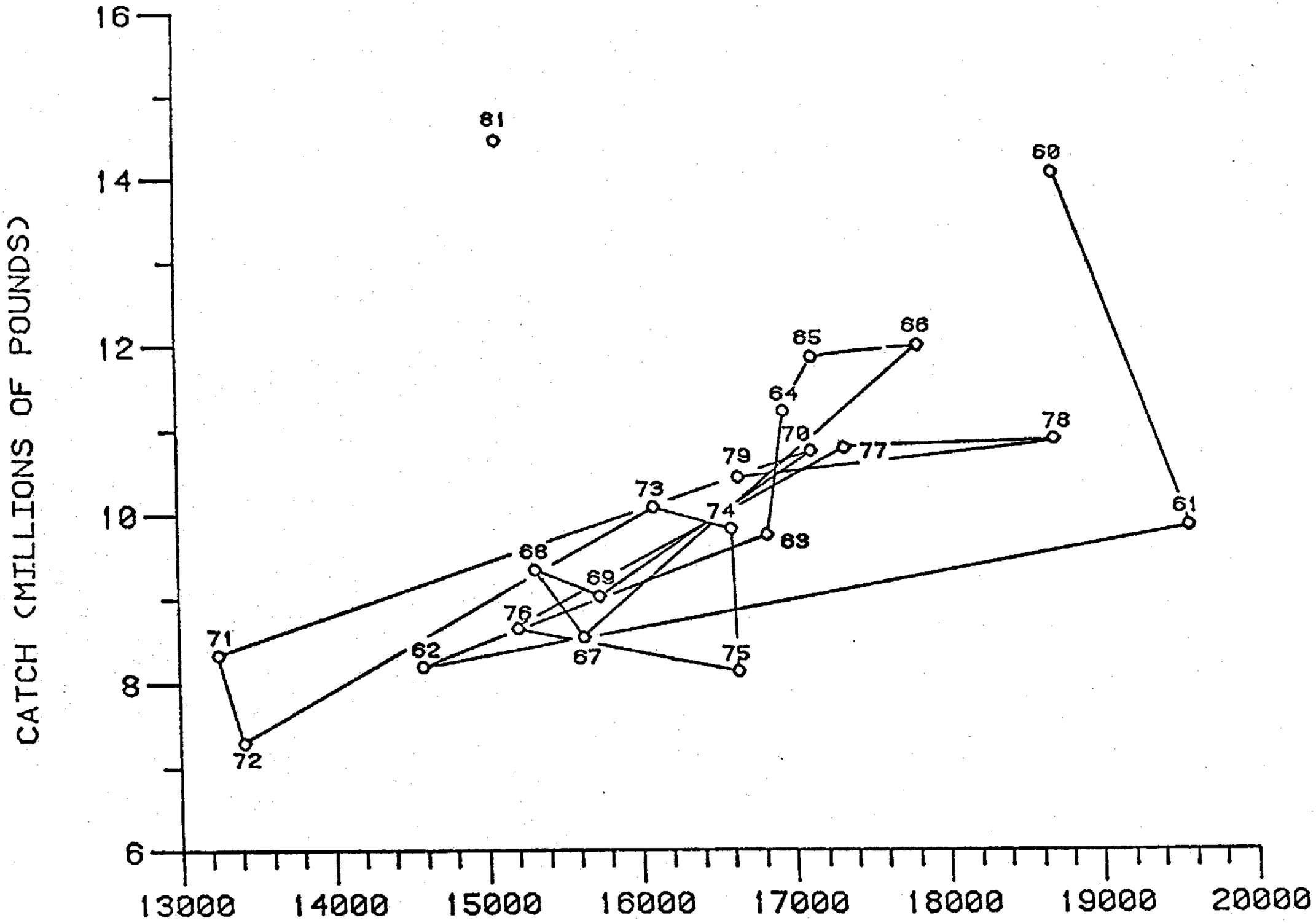

Figure 15. Catch versus fishing effort for 1960-1979 and 1981 from statistical subareas 1, 2 and 3.

Table 1. Number of vessels unloading shrimp caught in statistical subareas 1, 2 and 3 in 1981.*

Month	Key West, FL	Ft. Myers, FL
January-April	355	235
May	178	138
June	131	129
July	76	11
August	77	6
September	90	18
October	186	33
November	197	60
December	218	96

*Ernest Snell, DOC/NOAA/NMFS/SEFC, Miami, FL; personal communnication.

Table 2. Results of a 2-way analysis of variance (ANOVA) of monthly landings from 1960 through 1980.

Source	Degree of Freedom	Mean Square Error	F
Years	20	0.3668	3.378***
Months	11	7.4069	68.2213***
Error	220	0.1086	
Total	251		

***= significant at 99% confidence level ($P \leq 0.01$).

Table 3. Maximum nonsignificant ranges of average landings by year from the Student-Newman-Keuls tests.

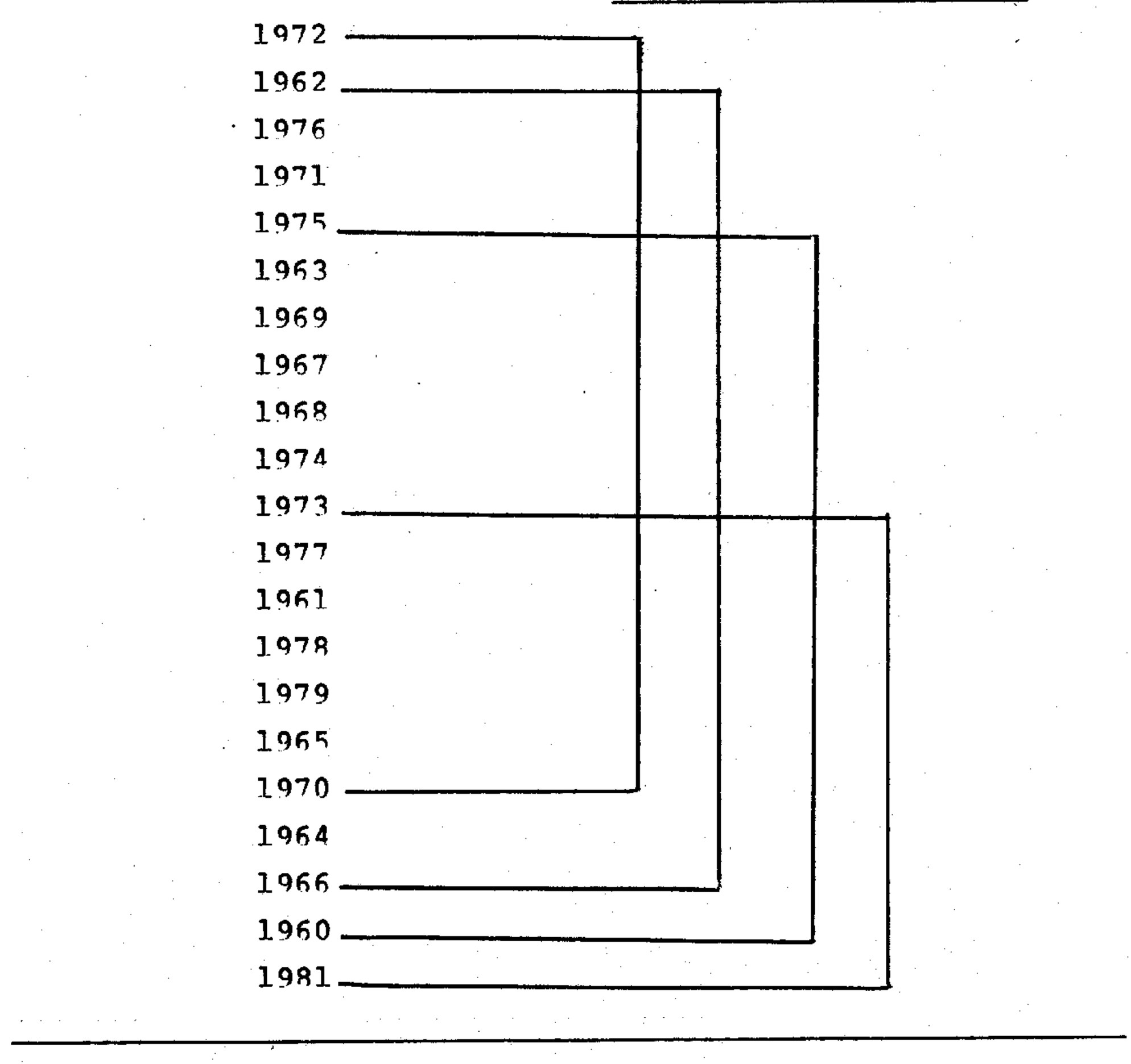

Table 4. Maximum nonsignificant ranges of average landings by month from Student-Newman-Keuls tests.

	Non-significant ranges
July	
August	
September	
June	
May	
October	
April	
February	
November	
December	
March	
January	

Table 5. Analyses of CPUE data from the Tortugas pink shrimp fishery.

A. Results of a 2-way ANOVA testing monthly CPUE for the period 1960-1979 and 1981.

Source of Variation	Degree of Freedom	Mean Square Error	F
Years	20	0.00007	2.3128***
Months	11	0.00035	12.5219***
Error	220	0.00003	
Total	251		

B. Results of paired t-tests for mean monthly CPUE for selected groups of years versus monthly CPUEs for 1981.

1960-1979 vs 1981	$t_{(11)} = 3.114^{***}$
1960-1964 vs 1981	$t_{(11)} = 2.476^{*}$
1975-1979 vs 1981	$t_{(11)} = 4.718^{***}$

* = P<0.05
** = P<0.001
*** = P<0.0001

Table 6. Results of Student-Newman-Keuls test showing the maximum nonsignificant ranges (by lines) in pink shrimp mean annual CPUEs 1960-1981, excluding 1980.

A. Mean annual CPUEs, 12 months each.

Non-significant range

1981
1960
1966
1964
1971
1970
1965
1979
1973
1974
1967
1963
1968
1978
1976
1969
1962
1977
1972
1961
1975

B. Mean monthly CPUES, 21 years each.

Non-significant range

October
November
September
December
July
August
January
March
April
June
February
May

Table 7. G-test comparisons of composition by size categories of pink shrimp landings from statistical subareas 1, 2 and 3.

Month	1960-1964 vs. 1976-1980 G. values	1960-1964 vs 1981 G. values	1976-1980 vs. 1981 G. values
September	27.0	28.9	16.9
February	28.2	16.6	12.3 N.S.
March	26.0	48.3	68.8
April	24.9	18.4	65.8
May	27.4	34.9	85.8
June	20.0	52.3	32.8
July	34.7	73.7	51.5
August	83.7	66.5	59.5
September	46.7	45.7	7.6 N.S.
October	20.6	46.8	21.5
November	22.9	78.0	19.3
December	12.6	23.6	18.0

Significant values: $X^2_{.05(6)} = 12.59$

$X^2_{.01(6)} = 16.812$